

JANUARY 20, 1986

CHEMICAL & ENGINEERING

NEWS

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Commercial Detergents

Technical service is key
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CHEMICAL & ENGINEERING **NEWS**

JANUARY 20, 1986

News of the Week

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■ Man-made trace gases are changing the chemical composition of the atmosphere but their effects on climate and temperature are not understood. **Page 5**

■ White House Science Council report calls for stepup in funding of academic science, tax incentives for firms that support university research. **Page 6**

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Cover: Photo courtesy of BASF Chemicals

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Business

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Product Report

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FEDERAL R&D BUDGETS:

Deficit law will cut expenditures

The first step down the path to automatic budget cuts aimed at reducing the federal deficit was taken last week when the Office of Management & Budget and the Congressional Budget Office submitted their "Sequestration Report for Fiscal 1986" to the U.S. Comptroller General.

The report details the cuts necessary to reduce the estimated fiscal 1986 deficit of \$220.5 billion by \$11.7 billion. Most line items in the defense budget are cut back 4.9%, those in the nondefense budget 4.3%. Between them, Congress and the President exempted many budget items from the cuts.

Research, however, is not among the exempted programs. It is an inescapable fact that federal research program managers are going to have

less money to spend in fiscal 1986 than they thought they would have when the fiscal year began. Some agencies, like the National Institutes of Health and the Department of Defense, still will have more research money to spend in fiscal 1986 than they had in fiscal 1985 because Congress gave them fairly large budget increases. However, other agencies, such as the National Science Foundation, will be below fiscal 1985 funding levels because Congress gave them either small or no budget increases.

NSF's basic strategy in implementing the automatic cuts will be to protect its prior commitments. By implication, that means that people who already have received their new grants or grant increases are in reasonably good shape, says Edward

F. Hayes, head of NSF's chemistry division. Most of the strain will come, he says, in the area of competitively reviewed proposals. NSF says it will do its best to minimize any reduction in the number of proposals it funds. However, that means that the awards may be smaller than they would have been and that the increases NSF can provide for renewals will be limited. The agency probably will try to save some money by delaying the obligation of funds for instrumentation into the second or third year of a grant in cases where it is possible to do so.

Even before the budget cuts, the Department of Energy's research budget was down in 1986, but now it will be reduced even further. The automatic cuts will have the most serious impact on DOE's national laboratories, according to Elliot S. Pierce, director of the division of chemical sciences, "because, although we did send out money to them, we are now going to have to pull some of it back." And, he adds, "we will have to reduce the money that we will be sending out to universities for the rest of the year."

OMB and CBO's figures are now being checked by the General Accounting Office, which has to forward them to President Reagan by Jan. 21. He is to sign a sequestration order for the cuts on Feb. 1. The reductions will take effect on March 1, unless Congress comes up with a different package of cuts by then—an unlikely prospect. As painful as this first round of automatic reductions will be, the prospects for fiscal 1987 are even worse. The current round of cuts supposedly would reduce the 1986 deficit to \$208.8 billion. For fiscal 1987, the mandatory target is \$144 billion. □

Cuts wipe out R&D budget gains

\$ Millions	1986			1985 funding	% change 1985-86
	Final funding ^a	Enacted by Congress	Proposed by Administration		
DOD	\$33,493.3	\$35,219.0	\$39,176.6	\$31,128.0	11%
Air Force	13,046.0	13,718.2	15,578.5	13,424.1	-3
Navy	9,572.0	10,065.2	11,264.3	9,172.6	4
Army	4,563.1	4,798.2	5,279.9	4,349.0	5
Defense agencies	6,312.2	6,637.4	7,053.9	4,182.3	51
NIH	5,257.7	5,493.9	4,860.5	5,148.2	2
DOE	3,679.4	3,849.0	4,044.1	3,989.9	-8
Energy supply R&D	1,696.1	1,772.3	1,971.0	1,957.8	-14
Weapons R&D	1,051.4	1,065.3	1,211.6	1,027.2	-2
General science & research	655.9	685.4	685.5	730.0	-11
Fossil R&D	312.0	326.0	176.0	274.9	13
NASA R&D	2,638.3	2,756.8	2,881.8	2,462.6	7
NSF	1,458.3	1,523.8	1,571.2	1,501.6	-3
Commerce	1,199.9	1,253.8	1,056.8	1,362.3	-12
NOAA	1,083.2	1,131.9	948.8	1,239.2	-13
NBS	116.7	121.9	108.0	123.1	-5
USDA	894.3	934.5	870.4	942.4	-5
EPA R&D	213.8	223.4	212.4	188.9	13
TOTAL	\$48,835.0	\$51,254.2	\$54,673.8	\$46,723.9	4%

^a After application of automatic budget reductions.

Biotechnology Stock Strength Could Help Firms Attract Funds

Stock values soared in 1985, outperforming the market; biotechnology companies now have more options in their quest for financing

David Webber, C&EN New York

Biotechnology stocks regained the confidence of the investment community in a big way last year. Prices surged on a broad front, especially during the fourth quarter, eclipsing the rise of the overall stock market by a wide margin. As a result, small biotechnology-based companies looking for new financing, which has been restricted largely to private equity placements and joint venturing for the past two years, may now consider looking for investors once again where many of the firms raised their grubstakes: the public marketplace.

Over the course of 1985, the composite market value—the product of stock price and number of shares of common stock outstanding—of a group of 12 biotechnology-based companies soared 121%. During the same period (Dec. 28, 1984, to Dec. 27, 1985), the Standard & Poor's 400 industrials stock index climbed 28%. Much of the surge achieved by the biotechnology stocks—which reflect a cross section of firms involved in recombinant DNA technology, hybridoma-based technology, and support businesses in instruments and other materials—came during the fall. By mid-September, C&EN's biotechnology stock index had risen 35%. Between then and the end of the year, it rocketed another 64%. By comparison, the S&P 400 industrials index rose just 15% over the same 14 final weeks of the year.

C&EN's biotechnology stock index is based on the stock prices for Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, and Monoclonal Antibodies. To reflect developments in the biotechnology area, several firms will be deleted and several will be added to the company sample for the next report on biotechnology stocks.

To a certain extent, the general trend of any reasonably small biotechnology stock index at this point reflects the movement of Genentech stock prices. The South San Francisco company has a market value so much higher than any of its competitors', it strongly influences any interpretation of the market's direction. Nonetheless, Genentech's own good performance on the stock market in 1985 was not the only reason the index increased so sharply. Stock price gains—and large ones—were almost universal in the biotechnology area last year.

For instance, of 17 companies with some of the highest market values in the area (an enlarged version of the sample of firms used for C&EN's biotechnology stock index), all but one recorded rises in stock prices over the course of the year. The prices of eight of the 17 stocks more than doubled in 1985, and two more stocks came just short of rising 100%. It was a robust performance nearly across the board.

The market's vigor seems to have held into the new year. Between the final Friday in 1985 (Dec. 27) and the second Friday in 1986 (Jan. 10), many biotechnology stock prices rose strongly, notwithstanding the record tumble taken by the Dow Jones Industrials Average on Jan. 7. Genentech stock, for example, shot up to a 52-week record of \$76½ be-

fore closing at \$73¼, up 10% over the two-week period. Monoclonal Antibodies Inc. stock also rose to a 52-week record high price and closed at \$19½, up 15% during the period. One-year highs were also notched by California Biotechnology stock, which jumped 35% to \$17¼, and by DNA Plant Technology stock, which rose a more modest 8% to \$11¼. In other notable increases, per-share prices rose 18% for Biogen and 9% for Chiron over the two-week span.

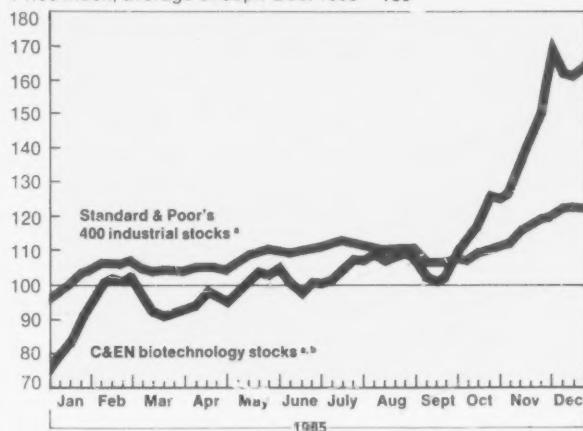
The continued muscle flexing is especially encouraging to some analysts, because it seems to echo January rallies in two previous years that set the tone for the next 11 months. In 1985, for example, the biotechnology stock index climbed 38% over the first six weeks of the year. Analysts hope the pattern repeats itself.

The surge comes at a fortunate time for many in the biotechnology area. Since the original bull market for biotechnology issues ended in 1983, the small companies have been forced to seek additional financing outside the stock market. Now many firms, having already dug deeply into the mounds of cash piled up during the first burst of enthusiasm for biotechnology, face the high costs of clinical trials, manufacturing scaleup, and the establishment of a marketing force. Most observers believe that access to capital in the coming period will determine whether companies remain in business, whether they remain independent, and what kind of operation they can become.

"We may see a more favorable financial environment with more interest in the biotechnology companies on the part of institutional investors this year," says Linda I. Miller, an analyst at Paine Webber.

Biotechnology stocks outran the booming stock market in fourth quarter . . .

Price index, average of Sept.-Dec. 1983 100



^a Reindexed to average for Sept.-Dec. 1983 period to show relative change. Prices as of Friday close each week. ^b Based on stock prices for Amgen, Applied Biosystems, Biogen, Centocor, Cetus, Damon Biotech, Genentech, Genetic Systems, Genex, Hybritech, Molecular Genetics, and Monoclonal Antibodies.

. . . and the value of many stocks more than doubled during the year

Company	Recent price ^a	% change ^b	52-week range	
			High	Low
Amgen	\$13 ⁵ / ₈	187%	\$15 ³ / ₄	\$ 4 ¹ / ₂
Applied Biosystems ^c	29 ³ / ₈	103	30 ⁷ / ₈	13 ³ / ₈
Biogen	14 ³ / ₈	161	18 ⁵ / ₈	4 ³ / ₄
Bio-Response	7 ¹ / ₈	78	9 ³ / ₈	3 ³ / ₄
California Biotechnology	12 ³ / ₄	132	15	5 ¹ / ₂
Centocor	23 ¹ / ₂	169	27 ¹ / ₄	8 ¹ / ₄
Cetus	28 ¹ / ₈	213	33 ³ / ₈	8 ³ / ₈
Chiron	12 ¹ / ₂	186	15 ¹ / ₈	4 ¹ / ₄
Collaborative Research	5 ¹ / ₈	17	7 ¹ / ₈	2 ³ / ₄
Damon Biotech	8 ¹ / ₈	76	9 ¹ / ₄	4 ¹ / ₈
DNA Plant Technology	10 ³ / ₈	196	11 ¹ / ₄	3 ³ / ₈
Genentech	66 ⁵ / ₈	97	75 ¹ / ₄	33 ³ / ₄
Genetic Systems ^d	10	86	10 ³ / ₈	5
Genex	1 ³ / ₄	-67	7 ³ / ₄	1 ³ / ₈
Hybritech ^e	30 ³ / ₄	92	32	15 ³ / ₄
Molecular Genetics	10 ³ / ₄	43	13	6 ¹ / ₈
Monoclonal Antibodies	17	89	19 ¹ / ₄	7 ³ / ₄

^a As of close on Friday, Dec. 27, 1985. ^b Dec. 28, 1984, to Dec. 27, 1985. ^c Adjusted for 2-for-1 stock split in March 1985. ^d To be acquired by Bristol-Myers, pending shareholder approval. ^e To be acquired by Eli Lilly, pending shareholder approval.

"There is more confidence now that the industry can deliver."

Seeking to exploit the renewed attractiveness of biotechnology stocks, two companies already have returned to the public market for financing. Centocor, Malvern, Pa., tested the water first, making a public offering of 1 million shares of common stock in December. The offering sold out at \$22.50 per share. Centocor, which last fall was frequently mentioned as a takeover candidate, perhaps whetted the appetites of investors. The firm says it will use the proceeds of the offering for working capital requirements including therapeutic product development, facilities expansion, and the proposed purchase of the assets of one of its R&D limited partnerships.

Also in December, Damon Biotech, Needham Heights, Mass., announced that it had filed a registration statement for a public offering of 2.5 million shares of common stock. The company is still waiting for the Securities & Exchange Commission to approve the offering. Word is expected by the end of the month, a spokesman says.

Analysts expect other companies—Chiron and California Biotechnology are rumored as likely ones—to make new offerings, too.

How deeply the stock market can

be mined by the biotechnology companies this time around depends both on stock performance in the coming months and on how the individual operations are perceived by potential investors. In a way, the second factor has not yet been as important as might be expected. The broad rise of biotechnology stock prices last fall was sparked by individual developments—acquisition agreements for Hybritech and Genetic Systems, FDA approval of Genentech's human growth hormone, promising results in trials of interleukin-2—but the effect seemed to manifest itself in a general fashion.

How much more stock prices will rise, if at all, depends on a number of factors. Analysts do not believe that the market will need more acquisitions on the order of those planned for Hybritech and Genetic Systems (neither has been concluded yet) to catalyze continued price increases.

"I don't know if we need more acquisitions to keep stocks up, but the acquisitions showed that there is a safety net to biotechnology investment," Miller points out. "The technology itself is of value. This was demonstrated by the acquisitions by large companies. There is now much less risk in participating

in a small company. Even if no money is made on products, value has been created."

Nonetheless, success in product development will determine the best investment candidates this year, analysts tend to believe. "One thing that makes me optimistic is that we can continue to expect good news from a variety of sources," comments Parag Saxena, assistant vice president in charge of the emerging health care fund at Citibank. "That will generate interest in the stocks."

According to Miller, "The stocks still have some up side, but whether it's 20% or 200% depends on the individual company." Saxena, too, expects the climb to continue. "The stock index will be at a higher number a year from now," he says.

In this climate of renewed enthusiasm for biotechnology stocks, it may even be possible for private biotechnology firms to go public. "I think the good-quality companies in their segments of the industry should be considering an initial public offering," remarks Miller. "Given the interest in the industry, a lot of them will be considering it. Those companies shut out of the public market one-and-a-half to two years ago should think about it. My guess is that the market would be receptive." □

Good growth forecast for engineering resins

Worldwide consumption of engineering resins will grow at an annual rate of 7% over the next five years to reach 4.8 billion lb in 1991 from 3.2 billion lb in 1986, according to James J. Conway, marketing director of Celanese Engineering Resins. For its own part, Celanese, a major producer of engineering resins, is responding to this growth by developing new resins and building plants and by acquiring technology and businesses. Most recently, the firm introduced a polyimide licensed from the National Aeronautics & Space Administration, introduced a liquid-crystal polyester of its own, bought a British compounder of engineering resins, and started an expansion of its Bishop, Tex., polyacetal plant.

In the U.S., Conway says, engineering resin consumption totaled 1.14 billion lb in 1985, an increase of 3 to 4% over 1984. Those figures include imports and plastic alloys. A slow economy will hold the 1986 rise only 4% to 1.19 billion lb. After 1987, Conway expects a more robust growth in the U.S. to about 1.78 billion lb in 1991.

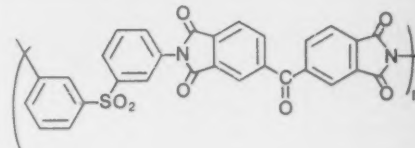
In this country, the largest outlet for engineering resins is transportation uses, which took 345 million lb in 1985, or 30% of the total.

Conway expects such applications to grow 9% per year to reach 590 million lb by 1991, which still will be one third of total engineering resin use. The second largest market is electrical and electronics, which accounted for 285 million lb in 1985, or one fourth of all engineering resins. Growth at 11% per year will lift this segment to 535 million lb in 1991, which will be a 30% share.

Another important market segment is a broad category that includes consumer goods. Conway says that increasing consumer acceptance of engineering resins in packaging and housewares will buoy this market at an annual rate of 7% to 340 million lb in 1991 from 230 million in 1985. Industrial goods consumed 150 million lb of engineering resins in 1985. The industrial market will grow 5% annually to 195 million lb in 1991, Conway says.

The one loser among engineering resin applications is construction, where the 135 million lb of engineering resins used in 1985 will shrink 1.5% per year to 125 million lb in 1991. Celanese managers attribute this decline to market saturation, erosion of the contribution of engineering resins by other plastics, and changes in definitions. Appearance of market saturation and penetration by other plastics will stem any growth in construction

NASA's new polyimides



applications. A drop in absolute terms will come from reclassification of some construction uses as industrial.

By a number of recent actions, Celanese is hoping to gain a share of the predicted growth in engineering resins—for instance, production of a NASA-developed polyimide. The polyimide is made from 3,3',4,4'-benzophenonetetracarboxylic dianhydride and 3,3'-sulfonyldianiline. Celanese Engineering Resins general manager John B. Downard says the company is making it in developmental quantities now, with full commercialization expected in the late 1980s.

The polyimide sulfone (PISO) is part of a series developed at NASA's Langley Research Center, Hampton, Va., by polymer chemist Terry L. St. Clair and David Yamaki, who was then a chemical engineering undergraduate at Massachusetts Institute of Technology. NASA has licensed a similar resin, which uses 3,3'-diaminobenzophenone as the diamine, to Mitsui Toatsu of Japan. That company's U.S. branch imports the product into the U.S. in developmental quantities as a polyamic acid adhesive and laminating varnish, and as fully imidized molding powder and film.

In a further move, Celanese has acquired Whitfield & Son (Plastic Compounds) of Telford, England, from English China Clays. Staff members of the acquired company are experienced in compounding highly specialized engineering plastic formulations for the electrical/electronic, automotive, and consumer/industrial markets. Celanese managers expect that the on-site color matching, formulation, and compounding capabilities of the new, 45,000-sq-ft Telford plant will allow more rapid response to specific customer needs. □

Engineering resins use topped 3 billion lb in 1985 . . .

Millions of lb ^a	U.S.	Rest of world	Total	% change in total from 1984
Nylons	415	917	1332	5%
Polycarbonate	315	359	674	4
Polyphenylene ether	155	194	349	-2
Thermoplastic polyesters	120	158	278	8
Acetal	118	424	542	6
Polyphenylene sulfide	10	10	20	0
Others ^b	9	5	14	0
TOTAL	1142	2067	3209	4%

. . . and is reaching for 5 billion lb in 1991

Millions of lb	1985	1986	1991	% change 1985-86
U.S.	1142	1190	1780	8%
Japan	677	724	1014	7
Western Europe	1114	1181	1580	6
Other	276	290	410	7
TOTAL	3209	3385	4785	7%

^a Includes imports and alloys. ^b Includes polysulfone, polyarylsulfone, polyether sulfone, polyimide, polyetherimide, and polyamide-imide; excludes fluoropolymers and acrylonitrile-butadiene-styrene. Source: Celanese



Commercial Detergent Surfactant Makers Rely on Technical Service

Patricia L. Layman, C&EN London

For manufacturers of surfactants, the commercial market—sometimes called the industrial and institutional market or I&I market—is a perplexing one. It is in itself large, but much smaller than its counterpart business in household soaps, detergents, and cleaning products. And it is even more highly fragmented than the household business. In other words, the commercial market is worth selling into, but only after recognizing the special difficulties involved.

Basically this business consists of cleaning products formulated for in-

dustrial, commercial, and institutional uses. The major end uses include dry cleaning, commercial dishwashing, commercial laundry, commercial hard-surface cleaners (which comprise cleaners for bath and tile, floors, and metal), carpet cleaning, car washes, and cleaners for the food-processing industry. Thus, the finished-product nature of the business distinguishes it from the classic industrial surfactant business, in which surfactant chemicals tend to be hidden in a process or product and employed as an aid or assist.

The business for commercial products, in fact, is quite similar to that for household soaps, detergents, and

cleaning compounds: finished formulations fulfilling the same cleaning functions, but for different locations. The difference, however, is large enough to complicate life for the industry, and for raw material suppliers selling to it.

U.S. sales of such industrial and institutional cleaning products are more than \$3 billion per year; that is, sales of finished, formulated products. Surfactants are only a part of that. However, in North America the business consumed some 400 million lb of surfactants of various kinds in 1985, according to estimates by consultants C. A. Houston & Associates, of Mamaroneck, N.Y. Mal-

PPG Industries diversifies into surfactants business

For PPG Industries, getting into the surfactants business has been a decision reflecting a great deal of serious thinking.

"Like so many large chemical concerns, we have been studying our portfolio of businesses, and have decided that diversification into specialties is the way to go," says Robert C. McQueen, surfactants program manager. "But everybody and his brother are doing that."

The company finally decided on specialties after studying the specialties fields open to it and going through an elaborate screening program. Several areas were chosen, one of which was surfactants, says McQueen. PPG saw a technical fit between its process know-how and the technology and requirements for surfactant molecules. This led to the development of the new line of surfactants—anionic sulfonates—it introduced in December.

About two years ago, PPG began its R&D in surfactants at its research center in Barberton, Ohio. The sulfonates are the first fruit of that work, and two other lines are scheduled to follow. One is slated for introduction the middle of this year and the other in 1987. Both of these feature technology related to the sulfonation know-how PPG already has tapped into.

According to McQueen, after investigating the surfactants business, "the thing that intrigued us was the breadth of applications for surfactants. And there had not been that much new technology developed in the past sev-

en to 10 years. We thought we could make a contribution."

The company knows, however, that it can't get there alone. "We will be embarking on a series of acquisitions in the specialty surfactant field" to reach a reasonable size—a critical mass, McQueen says. PPG's work will be strictly with specialty surfactants. "We want to avoid commodity areas. We have no intention of competing, for example, on nonyl phenol ethoxylate, even though we make ethylene oxide."

The first move on the acquisition trail was announced earlier this month when PPG acquired specialty-surfactant supplier Jordan Chemical, of Folcroft, Pa., for an undisclosed sum. PPG management said at the time that the Jordan acquisition would help PPG penetrate the market with its new surfactants and give presence and identity in key market areas.

The company describes its own new surfactants as novel sulfonates. "There have been some isolated references in the literature to them over the past decade, but no one had commercialized them," says McQueen. Admittedly, he adds, they are difficult to manufacture, but PPG can handle the technology. The new line is in the pilot-plant stage in Barberton, and PPG expects to offer commercial quantities by the second quarter of this year.

The new sulfonates are much more stable than sulfates over a wide pH range, from highly acid to highly alkaline, McQueen says. For example, lau-

ryl ether sulfonate is more stable than the lauryl ether sulfate workhorse of shampoos. Under similar conditions, he says, other surfactants come apart and cease to function.

PPG sees a wide range of applications for the new sulfonates. In cosmetics, they may fill a specialty niche in combination with commodity surfactants. The mildness of the sulfonates make such markets an attractive potential. Simply because of economics, however, the sulfonates would not be desirable as the primary surfactant, McQueen points out; they are high-priced specialty items. Also, their compatibility with germicidal actives makes the sulfonates suitable for germicidal hospital scrubs. And their emulsifying properties allow them to be used for a host of industrial applications, from polymerization to agricultural chemical emulsification to enhanced oil recovery.

The materials essentially consist of a sulfonate attached to a polyoxyethylene, with ethoxylation ranging from three to 15 moles of ethylene oxide. Pricing is roughly triple that of the comparable sulfates. "That is why," McQueen says, "we are saying specialty. Downstream a bit, we might be able to close the [price] gap some, but we will never close it completely."

Next in the company's venture into surfactants will be a line of novel quaternary ammonium compounds—both surfactant and biocidal products. The third, low-foam line of surfactants probably will be out in early 1987.

colm McLaughlin, project leader there, says the U.S. market for surfactants in those products is about 360 million lb per year, with another 40 million lb consumed in Canada. In Western Europe, the market for surfactants for such commercial products is about 287 million lb, with a manufacturers' value of about \$150 million.

The U.S. market is so much larger because of three market segments—detergents for hard surface cleaning, metal cleaning, and commercial rug cleaning. Those products are used more commonly in the U.S. than in Europe. However,

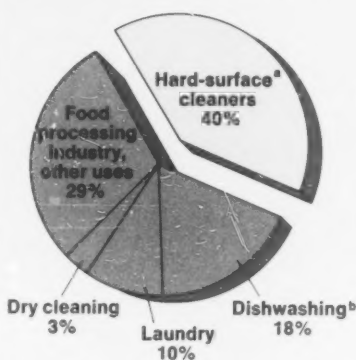
the market for cleaning products for commercial laundries is significantly larger in Western Europe than in the U.S. One reason, explains McLaughlin, is that "there is a larger seasonal hotel and restaurant linen-cleaning business in Europe than in the U.S."

Between 1979 and 1985, revenues for companies selling formulated products aimed at commercial uses averaged 4 to 7% growth per year. But for the second half of the period, growth has been at the lower end of that range. Net earnings for all companies increased only slightly, and they declined for some indi-

vidual firms. For this business, which considered itself a money-minting industry during the 1960s and 1970s, that has been a bit of a shock.

McLaughlin suggests that though the problems were basically the result of the recession, several other major factors were involved. For example, a strong dollar adversely affected those U.S. companies in the business that have strong overseas operations. And the business has become increasingly more competitive. It is a service industry that has no secrets. All a potential marketer needs is a bit of detergent chemistry—which can come from a friend-

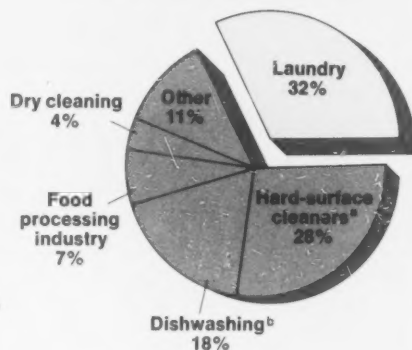
Hard-surface cleaners lead in North America ...



1985 Total commercial surfactant market = 400 million lb

^a Includes bath and tile, floors, metal ^b Includes machine and hand washings.
Source: C. A. Houston & Associates

... but in Europe, laundry tops surfactant market



1985 Total commercial surfactant market = 300 million lb

ly raw materials supplier—and a few contacts. That is a simplification, of course, and doesn't represent the heavy R&D effort and expenditures of the major companies in the business. But it can be quite true of small firms, which slip into the market and serve equally small, and sometimes sizable, customers.

Whatever the reasons, the industry has been troubled—so much so that some formulators are now for sale. The situation is getting better, however. For example, the office building boom is still having an encouraging effect on commercial sales, even if many of those new buildings are unoccupied. Also, the ever-increasing use of carpeting, rather than say, hard tile, boosts the sales of carpet cleaners.

According to the Houston studies, though U.S. and Canadian markets are mature, they will grow 2.5% per year for the remainder of the decade, while still-developing Mexican markets will grow more than 10% per year. In Europe, where the business has slowed some, future growth for commercial and industrial process surfactants is pegged at 2 to 3% per year above gross national product, with earnings rebounding to former good health. The commercial market, which is half of the total European surfactant industry, is expected to grow faster than the industrial-process aid market. Moreover, new business op-

portunities arise as a result of marketing, environmental, and technical shifts in the various geographical areas.

This almost could be considered a motherhood market; the demand for clean, sanitary public facilities and for fast, efficient products requiring low manpower is increasing. Also, changing consumer habits, particularly for dining, are benefiting the restaurant and hotel trades as well as fast food chains. These are both large consumers of institutional products, and are among several of the market sectors for commercial cleaners expected to show the highest growth over the next five years. Contract and janitorial cleaning of shopping malls, retail stores, and small firms is also benefiting from a reviving economy.

A reviving private economy, however, still has not spilled over to boost public spending, so commercial segments that depend on public allocations—for example, cleaning of schools and colleges, and of hospitals and nursing homes—are still growing slowly, if at all. That is true even though public health concerns are increasing and have the potential to heighten the demand for disinfectant and sanitizer products.

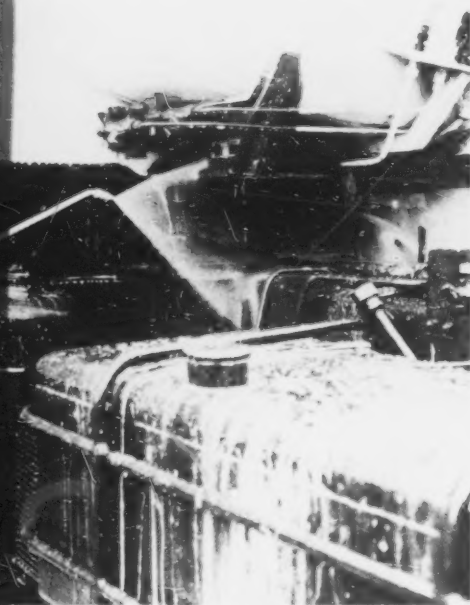
Whatever the market segment, whatever the kinds of products being formulated and sold, one generalization probably describes the

industrial and institutional business: It is highly fragmented. There are more than 2000 formulators. Only a few are large, nationally known companies, such as Diversey, a subsidiary of Canadian brewer Molson; Economics Laboratories; DuBois; Chemed; and National Chemsearch. According to some estimates, it is likely that the top 10 companies have less than 50% of the business. Instead, most of the industry consists of small regional or local "mom and pop" operations.

The market is very fragmented in Europe, too. The biggest difference is that the major European household soap and detergent companies—Henkel and Unilever—dominate the commercial business, too. They play a large role, for example, in supplying commercial laundries with formulated products. In the U.S., Procter & Gamble, Colgate, and Lever are in the commercial business hardly at all. However, in other market sectors, such as office cleaning, the European market is even more fragmented than the U.S. market. There are several second-tier leaders, such as Joh. A. Benckaiser, which operates in several countries. But there are few identifiable leaders; the markets tend to split more on a country or regional basis. In fact, looking at the industry worldwide, Henkel is the largest, followed by Diversey, Economics Laboratories (excluding its consumer sales), and Unilever.

Raw material suppliers agree that if anything, the number of companies in the business has not shrunk but expanded. It is easy to get into most commercial businesses. The costs aren't high, and all that's needed is a few tanks, somebody to mix, and some know-how in operating with specialty chemicals. For example, Diversey helped build its business by buying units from companies more accustomed to raw material and intermediate chemical production. It bought an industrial machine dishwashing business from U.K. chemicals producer Albright & Wilson, the Wyandotte commercial laundry business from BASF, and the metal-industry cleaning business from West German chemicals giant Hoechst.

Observes a Diversey executive,



Vehicle being cleaned with Henkel's environmentally safe detergent P3-grato 12 at Frankfurt Airport

"These large companies sold willingly, recognizing that it is far more advantageous for them to supply raw materials to Diversey and leave the solving of the cleaning problems of many thousands of customers to us and to firms specializing in specialty cleaning chemicals as we do. Removing the tea stains from the cups in a cafeteria at the end of Brighton Pier is a long way to go to sell 50 kilos of product."

Just as suppliers tend to shake their heads in wonder at the number of formulating companies in the business, they also comment on the thousands of products that are made. Diversey, for example, sells more than 3000 products into its six major target markets. Most formulated products aimed at industry and institutions are highly specific and small volume.

Like the products sold in the various markets, the raw material suppliers to the industry are many and varied. That can complicate things for suppliers.

For example, selling into the commercial business is different from selling into the household business. Says one supplier: "The linear alkylbenzene sulfonate sold to the household soap and detergent industry would be sold on a long-term con-

tract basis, but industrial and institution purchasing tends to be on a bid-awarding basis."

Major producers of surfactants—companies such as Vista Chemical, Union Carbide, Shell, and Monsanto—serve the commercial business, but more or less as an addendum to the bulk of their sales, which go into the household soap and detergent business. One of the major advantages they have in most of their operations, dealing with an equally large supplier, is lost in an industry of 2000 customers, most of whom are small. So smaller suppliers of surfactants and other raw materials have found the commercial business a lucrative market, one in which personal contact is important, and one in which specialty products can win the day. That leaves things wide open for companies willing to do the specialty work, or whose products lend themselves to the particular needs of industrial and institutional products—suppliers such as BASF Corp.'s chemical division, Witco, Rohm & Haas, GAF, Emery, and newcomers such as PPG Industries. Customers can be extremely loyal to that kind of service; it is not unusual for suppliers to have customers for 20 years or longer.

Small customers frequently turn to their suppliers for help with formulations and other technical services, which might be thought a more natural strength of large surfactant suppliers. However, the assistance large suppliers offer all too frequently concentrates on commodity surfactants, not on the specialty products needed in the commercial business. Moreover, the major companies serving the commercial business, such as Chemed, DuBois, Economics Laboratories, and Diversey, all provide service, anyway.

Chemical raw materials suppliers selling into the business, then, must use different sales aids, offering complete packages of surfactants and other formulation ingredients. They also must work hard to develop effective distribution/distributor networks.

Notes one supplier, "You have to take a sales and distribution outlook on this. We sell directly to the top companies in the industrial and

institutional business, but most of our sales are through our distribution network. That entails educating our distributors just like we would the major customers. Our distributors have to give the technical service, too. And of course, we have to do all this at a competitive price."

Large- and small-volume raw materials also can pose problems for suppliers. In an industry where 500,000 lb can be considered a major order, companies tend to devote most of their attention and technical service in-house to the major product lines. Smaller-volume products are, in turn, passed along to the distributors, who must supply such information as the different formulations a supplier is currently recommending, under which conditions each might be recommended, and what other factors are important.

But all that is nothing new to the actual marketers of commercial products, who face almost identical problems with sales, distribution, and technical service, whether in the U.S. or in Europe. For them, the notion of "package" is becoming increasingly important—almost to the point of necessity.

Systems, of course, have been the talk if not the practice of the commercial business for years. For example, Stauffer was touting systems—dispensing systems and cleaning formulations—for the commercial dishwashing industry in the early 1970s, when it was still in that business. But now systems have moved from the discussion stage to become part of life.

As one marketer at Henkel, the Düsseldorf-based chemical products manufacturer, puts it, "We are selling a package deal: the product, the service, the equipment, the know-how." In some areas, such packages are especially crucial. A Henkel product developer adds that "in dishwashing, without automatic dispensing systems, you couldn't sell 1 kilo of product. All our competitors have [automatic systems]—it is the state of the art—so now it depends on who has the better systems."

"It is a service approach. We must be a consultant," says one marketer. "It is not necessarily that we

have products better in composition, but better in application. We want to know more about application than the customer does. We are problem solvers." Explaining the rationale behind his thinking, he adds, "Selling a package deal creates a certain dependency for customers. They can't substitute chemicals so easily."

Henkel's marketers would agree. "The important thing to get away from is consumer-products thinking," says one. "We are selling chemicals and solutions, not just products. In the industrial and institutional business, we need to put across the idea, 'If I change Henkel products, I change my entire system, and I can't afford to do that.'"

Much of that comes down to a recognition that, for selling in the industrial and institutional market, the critical factor is cost-performance ratios. In the household-products sector, on the other hand, selling is based on a number of other benefits. Marketers, for example, can advertise benefits such as softness. The inability to do that serves only to intensify the competition within the commercial business.

Meeting the competitive demands can be an expensive business, but marketers deem it worthwhile. What helps is in-house capabilities for equipment design and production. Henkel, for example, has several companies that can do the engineering and construction of dosing and control units for various commercial applications.

Within the past several years, Diversey acquired Beta Co. in Santa Cruz, Calif., for making dispensing equipment. The acquisition was necessary, Diversey marketers say, "to meet the demands of the sophisticated market" of the 1980s. As one marketer explains, "In the 1980s, we found ourselves using micro-processor systems for the automatic cleaning of plants, and machine-dishwashing metering devices incorporating a voice synthesizer that gives instructions to the operator when the detergent or rinse-aid must be replenished or the temperature is falling. Customers now demand and must be given reliable equipment."

Besides, another marketer adds,

"We have found the market ready and willing to pay extra money for better and consistent results."

Obviously, even for service-conscious marketers, there is a limit to the amount of service that can be provided. For example, rarely would an on-premise laundry, such as one located in a hotel, be serviced directly by a larger formulator. That would be done by dealers who specialize in looking after this market. They know the basics of the process and can solve a lot of problems directly, or can consult with the formulator. An order of perhaps "3 tons per year would justify direct service from us," says one Henkel marketer.

Similarly, for Henkel's metal-cleaning unit, direct service would be provided with orders of 3 tons or more. Product development staff members point out the sheer logistical problems of working otherwise. In West Germany alone, they say, there are more than 100 direct customers for preanodizing cleaners. Some service and training has to go by the boards.

"We can't train for every single plant," says one researcher there. The company can, however, make sure the customer has access to its expertise in the system, even in metallurgy in its metal-cleaning group. And, on occasion, it has intervened for its customers with their other suppliers—much to the resentment of those suppliers who didn't appreciate their bargaining power suddenly shifting dramatically.

When the company provides training, however, the training accompanies the sale of a system and is given locally, incorporating all the expertise the firm has gathered. What is emphasized and what is recommended would be different, say, in Nigeria than it would be in Japan—different systems are adapted to local markets. This necessity was recognized in the 1970s, when Henkel started regional development, including founding new companies. It has just started a technical training laboratory in Bangkok for its own people and for customers, to serve all Southeast Asia except Japan.

Before, one marketer at Henkel recalls, "We brought our customers

here and trained them here. Then when they went back, there was a 'culture' shock. We had to train them for what they would find there—supplies, working conditions, and so on." The local training is also augmented with traveling engineers, company specialists in the various industries. They train both Henkel people and customers, start up new lines, even do market surveys.

What it comes down to, marketers for the commercial business agree, is that they must be able to say truthfully, "We know the markets, and we have the staff." The staff has to be expert in the field, understanding the composition of the various products, how they are supplied, and what they do to the goods being cleaned, as well as how each machine involved functions.

It is difficult for any one company to show strength in all the various commercial segments—there is the danger that its expertise will be spread too thin. The large companies such as Henkel can do it, but they are rare. More commonly, firms specialize.

For example, in its European markets, Lever is particularly strong in commercial textile hygiene. Major competitors within the kitchen hygiene sector include Diversey and Economics Laboratories. In the field of hospital disinfectants and sanitizers, Chemed in the U.S. is especially strong.

Market end uses such as cleaners for the food processing industry, agricultural processing, and metal cleaning are the major industrial part of the business. Cleaning products for the food and beverage industries, for example, would be sold for a variety of applications—dairy; beer, beverages, and bottled water; meat/slaughtering; and can cleaning. Agricultural cleaners include applications such as cow cleaners and sanitizers, and special sanitation uses such as cleaning out chicken houses.

Institutional uses include detergents for laundries, dishwashing, hospital hygiene, and janitorial cleaners.

Each field is, of course, affected by different factors. For example, in the commercial laundry business,

Chemical suppliers are taking hard look at service they provide

The commercial detergent business has always been highly service oriented. Many of the companies that actually sell formulated products also offer service to their customers—for instance, dispensing equipment, employee training programs, and so on.

Similarly, raw material suppliers historically have offered a great deal of service to their customers, the product formulators. This makes it easy for someone to enter the formulator market. As one industry analyst points out, "There is no secret to service. All you need is a bit of detergent chemistry, which if you don't have, you can get from your friendly raw materials supplier, and off you go."

Chemical suppliers provide a variety of sample formulations, for example. And they are also the ones who provide safety and efficacy data when they are needed. That's particularly important for the quaternary ammonium surfactants side of the business, where quaternary ammonium compounds function as biocides for disinfectants and fungicides for hospitals and other institutions, as well as for uses as diverse as water treatment and downhole oil drilling.

Clearance for such applications (and marketing claims) relies on a battery of toxicity and efficacy tests, mandated by federal, state, and local governmental bodies. These tests take time, and their cost can be significant—certainly much higher than many of the 2000 commercial formulators

can afford to pay on their own. Because governments are asking for more and more data, these tests will become ever more costly in the future.

Some signs are surfacing, though, that chemical suppliers may be starting to rethink this situation. If some of them decide to discontinue offering service, this would be a fundamental change for the industry, and would affect both suppliers and formulators. Early indications are that the changes would begin occurring first in the quaternary ammonium surfactants business. However, if they were to happen there, where they would have the most impact, such a move could easily spread to other areas of the commercial detergent business.

Basically, the problem affecting the quaternary ammonium surfactants industry has been an influx of producers over the past few years into what is a rather small business. It used to be dominated by two companies, Onyx and Lonza. But other companies have expanded their operations or jumped into the business. Huntington Laboratories, which used to be solely a formulator, now also sells quaternary ammonium surfactants on the merchant market. Likewise, Jordan Chemical, Emery, Henkel, Hexcel, McIntyre, Rohm & Haas, Scher Chemicals, Hilton Davis, Sherex, Akzo Chemie, and Mason Chemical also have entered the business. And PPG Industries' new family of surfactants will include a line of

quaternary ammonium surfactants, both for regular surfactant applications and for biocides. The result is that prices have taken a nosedive, causing low margins and low returns.

Typical for a well-established market with a significant influx of producers, much of the competition has focused on prices—low prices for "commodity" quaternary ammonium surfactants and little service. Companies that still rely heavily on service to sell their products are finding that more and more a disadvantage. Service always has been an expense to be absorbed, but as quaternary ammonium surfactant prices have fallen, the margin into which those expenses could be absorbed has grown smaller and smaller. That is one reason why, as one supplier notes, "The money is being made by the formulator, not the supplier."

"Customers are willing to put you over a barrel to match the prices of the guy who isn't offering any service," grumbles one quaternary ammonium surfactant supplier. The result is that suppliers are taking a hard look at the service they provide. They are considering two basic options: turning away from their traditional service orientation completely or offering it strictly on a pay-as-you-go basis. "We all used to be very service oriented, but that has changed," says the supplier. "Now it comes down to the question: How much are we going to continue to do?"

the on-premise laundry, which tends to be a small operation, is shrinking in market share, whereas the market share held by the large individual laundries is growing, frequently by concentrating small outlets. The market for commercial dishwashing is growing, too, as the restaurant business expands.

On the other hand, the market for hard-surface cleaners, at least for the time, is stagnant, primarily because the public sector, an important component of the business, has cut budgets. Such budget cuts haven't frozen all industrial and institutional spending, however. The hospital hygiene market, for exam-

ple, is growing "tremendously," according to one enthusiastic marketer.

On the industrial side, one of the major end-use applications is in metalworking, and in this, the automotive industry is most important. Commercial cleaners remove oils, greases, and dirt that are found on delivered metal. Their use is especially important before precoating preparations such as phosphating, anodizing, and galvanizing are done, and before enamels, coil coating, or other coatings are applied. Commercial products also are used to clean metal products prior to shipping, and for general-purpose cleaning of vehicles.

Sometimes companies selling these kinds of cleaners can find ways to integrate their product lines. For example, in the metalworking cutting fluids market, Henkel recently began a program of vertical integration. Its theory is that because it sells cleaners to remove metalworking fluids, it can better control the system if it sells the cutting fluids, too.

Markets in different geographical areas are growing at different rates. Some countries and products still show double-digit growth, although those examples admittedly tend to be infrequent. Developing markets continue to offer opportu-

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PER-OXYGEN BLEACHING

Product Report

nity. For example, Nigeria has built 20 to 30 new breweries in the past five years. The potential for bottle cleaning agents there has grown 100% per year—to the point that the market just for bottle cleaners is now 12,000 metric tons per year.

Marketers cite India's auto making as a similar case. Within the next five years, India will have five auto manufacturing lines, so it will be a major market for metal-cleaning products.

Even developed countries can still offer growth in selected market sectors. For example, over a 10-year period, the aluminum container market in the U.S. increased tremendously to the point of virtually replacing steel for beverage cans. Firms that sold surface-preparation cleaners for aluminum grew dizzy from the fast-paced growth.

More commonly, however, growth does not exceed the increase in GNP. That helps explain the pressures on companies in the commercial detergents business to find new product lines, new market areas—niches where markets are growing.

One factor that formulators for this business will be counting on in their search for new markets or new products will be raw materials, particularly surfactants. At present, in the household detergent industry, anionic and nonionic surfactants roughly share the market. For the commercial business, however, nonionics dominate, accounting for nearly two thirds of the surfactants consumed in the industry.

The major nonionic family for these commercial uses is the ethoxylates, which serve as the industry's workhorses. Nonelectrolytic, they function as good wetting agents, detergents, emulsifiers, and dispersants in a host of formulations—and at an attractive price.

The most widely used surfactant is alkylphenol ethoxylate, followed by alcohol ethoxylate. The market is relatively stable, suppliers report, with growth tracking that of GNP, and has shown no dramatic changes. In particular, because there are a host of suppliers for alkylphenol ethoxylate, the supply of this compound is greater than the demand. Therefore, customers benefit from price competition—or price deteri-

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CIRCLE 27 ON READER SERVICE CARD

Product Report

oration, according to one supplier. Linear alkylbenzene sulfonate, the workhorse of the household soap and detergent industry, is the third largest surfactant for commercial formulations, but the amount of it sold for commercial uses is overwhelmed vastly by the volume consumed by household detergents. It is no wonder that producers pay most of their attention to the household market.

Alkylphenol ethoxylates, however, are under a cloud because of sluggish biodegradability. The major marketers in the household detergent industry, for example, have a voluntary agreement to not use these compounds in their products because of concerns on this score. Some major commercial-product makers, such as Henkel, have abstained voluntarily from using alkylphenol ethoxylates for institutional cleansers and intend to withdraw their use from industrial compounds as soon as they have developed suitable substitutes. However, most companies in the economically squeezed commercial business depend on them.

How much of a problem this is has been debated extensively, but some suppliers don't yet believe the question has been resolved. Says one: "I'd like to go back and reargue the biodegradability question, with comparison to alcohol ethoxylates [often recommended, because of better biodegradability]. There is a 10 to 15 cent-per-lb premium for those materials because there is some evidence, maybe, that they biodegrade quicker. I don't think you need to pay that kind of premium. The evidence argues that materially there isn't that much difference in the rate; it is in percentage points, not factors of 10."

Industry observers note that, at present, no move is under way to remove alkylphenol ethoxylates from commercial products. The market for such products is much smaller, of course, than the household one, so presents much less of a cumulative problem. And because the number of even halfway large companies is so small, there are no visible targets of consumerist wrath, as the larger companies in the household detergent industry could be.

Nonetheless, notes Houston's

McLaughlin, "Concern over the biodegradability and toxicity of alkylphenol ethoxylate residues will definitely lead to new product introductions in some applications."

Low-foaming characteristics, always important in the commercial business, will become even more important as these markets increasingly mirror the same trends occurring in the household soap and detergent industry—lower washing temperatures for energy and cost savings. Also, greater mechanization of systems means more of a demand for lowered foam. For commercial dishwashing, formulations need to be increasingly resistant to foam formation, as the processing times shorten.

BASF Chemicals, Rohm & Haas, GAF, and Olin are the major suppliers of low-foam surfactants for this business. Low-foamers include block copolymers and the alkoxylated straight-chain alcohols, which are good wetting agents that don't generate foam. BASF, for example, has built up its strengths in low-foam, block copolymer surfactants—ethylene oxide/propylene oxide blocks—sold primarily to formulators of dishwashing and rinse-aid products.

By 1987, PPG also will have joined the roster of suppliers of low-foam surfactants when it brings out the third line in a new family of surfactants. PPG marketers say the materials will be "something structurally similar to the ethylene oxide/propylene oxide block copolymers, but quite different—with lower foam and better detergency."

Other suppliers report a small but growing interest in short-chain nonionics, which are being used only infrequently at present in commercial formulations, and in new polymer builders for commercial formulated detergents.

BASF Chemicals, for example, has begun importing from its parent in Ludwigshafen acrylic-acid polymers as alternative builders. The polymers act as chelating agents and dispersants. In Europe they are already incorporated into some household detergents in phosphate-restricted areas. The company believes that the conditions under which commercial laundries in the U.S.

operate are similar to conditions for household laundries in Europe. Therefore, it decided that the polymers would be of interest to the commercial detergent business in the U.S. The polymers can tolerate higher temperatures, higher soil loadings, and a more concentrated washing system, BASF says. Its present marketing emphasis is the commercial laundry area, but at some point the polymers will be of interest for hard-surface cleaners, company marketers predict.

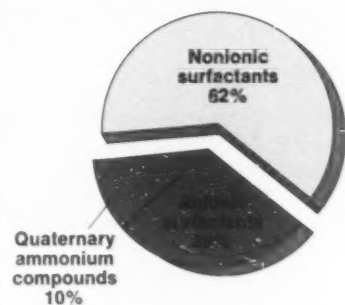
Temperature is a constant concern for customers, so formulators must be aware at all times of trends regarding this parameter—such as the economic pressures toward lowered temperatures. These, and more mechanization, are in turn driving the industry to products formulated as liquids. Liquids are easier to measure and dispense and have higher solubility. However, they are also a much more frustrating technological challenge, say Henkel researchers.

Customers who use liquids can automate a process more easily, with better meter and process control. All it takes is a little pump to meter the liquid into water. Dosing of powders can sometimes be complicated. Certain chemicals are hygroscopic, causing maintenance and sticking problems. Customers generally don't like to do any maintenance—and often, they haven't the technical expertise to do it.

However, "from a product technology standpoint, we can work more-sophisticated chemicals into powders," says one Henkel researcher. "With liquids, only about 50% is 'active,' and the rest is water."

Debates have persisted on the desirability of powder detergents vs. liquids—for example, shipping costs and packaging are different. Marketers say they are becoming increasingly concerned by the problem of having to get rid of the containers for liquids. Liquids require probably three or four times as many containers as solids, and they are bulky containers to boot, compared with the paper or laminate bags powders are sold in. The question of costs also must be addressed: Marketers don't accept containers back from customers for reuse, because

Nonionics dominate North American surfactant use



1985 Total commercial surfactant market = 400 million lb

Sources: Industry, C&EN estimates

of safety. But they agree that bottles will be a problem in the future when marketers may be forced to develop re-use applications, or reconditioning technology, or perhaps mobile shredding units—customers will demand it. These concerns will slow the move to liquids, several marketers predict, until the ease of automatic dosing carries the day.

If commercial products are manufactured more as liquids, that will be a major difference between that business and the household-products industry, which—at least in the laundry-detergent side of it—has refused to produce a majority of its products as liquids. But that would be one of the lesser differences between these two surfactant markets.

To commercial product marketers, the major difference between household and commercial products is that their companies are formulating and selling chemical systems designed to tackle completely different conditions. For example, in the commercial laundry business, "textiles get really dirty, and there are all kinds of fabrics done in one go," says one product-development specialist. "Household detergents don't have to face the same degree of dirt, and the housewife separates her laundry into batches." Moreover, whereas a home washing machine might have a one-half-hour cycle, a commercial machine would process a load in 15 minutes.

Similarly, a home dishwasher normally might take about one-half hour. In the big institutional dish-

washers, it takes 20 to 40 seconds for plates to go through the tanks. The actual transit time might be two or three minutes, and of that, the contact time with the tanks is only 20 to 40 seconds. Hence, formulations rely on much stronger chemicals and a pH frequently higher than 13. Sodium hydroxide is a major component of commercial dishwashing cleaners, which would never be used in household formulations, if only for safety reasons.

In some phosphate-restricted areas, legislation makes a distinction between household and industrial cleaners, so that phosphate still can be used as a builder in industrial cleaners. In a number of European countries, commercial product compounds have escaped regulations governing the biodegradability of antifoaming agents. But that situation is changing. For example, in West Germany this year, biodegradable antifoaming agents must be used for bottle washing and breweries. That has resulted in a switch from ethoxylated fatty alcohols to the corresponding ether derivatives. And West German law extends that mandate to all commercial market sectors by 1989. Other countries, including Switzerland and Italy, already have phosphate bans for laundry detergents, even commercial products. Austria is expected to follow suit soon.

Government agencies that regulate the environment have long been monitoring or controlling the wastes from commercial car washing. For example, the biodegradability and solvent accumulation, particularly from motor cleaning, have been measured. But in true "every problem is an opportunity" spirit, Henkel developed a formulation that, when concentrated, spontaneously emulsifies oils and solvents, but when diluted to one tenth, the emulsion breaks and the oil separates out. Dubbed P3-grato 12, it contains a nonionic surfactant, organic builder, corrosion inhibitor, and coupling solvent—but no phosphate, solvents, mineral oil, or emulsifiers. It has been approved—indeed, is required—for use at Frankfurt Airport on parking areas, for courtesy cars, and for motor cleaning to reduce the amount of oil in effluent washwater. □